

FLUE GAS CONVERSION APPARATUS AND METHOD

1 BACKGROUND OF THE INVENTION

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3 Field of the Invention

4 The present invention relates to an apparatus and
5 method of utilizing the flue gas mixture produced from
6 burning fossil fuels, particularly the gaseous carbon
7 dioxide constituent of the mixture, thereby eliminating the
8 release of greenhouse gases into the earth's atmosphere.

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10 Description of the Related Art

11 A recently discovered consequence of our industrial age
12 is an increase of the concentration of carbon dioxide (CO₂),
13 a trace element in our Earth's atmosphere. It is known that
14 just before the industrial revolution the CO₂ content of the
15 atmosphere was 280 parts per million (ppm). In 1989 the CO₂
16 content was a little over 350 ppm. This increase in a
17 relatively short period of time is an apparent indication
18 that an overload condition exists upon elements which behave
19 as natural sinks for this gas. These elements, namely the
20 oceans, vegetation, and rocks have so far been able to
21 function perfectly as natural sinks throughout the ages,
22 having only been exposed to the natural occurring sources
23 of carbon dioxide such as fires and volcanic sources.
24 However this recent addition by anthropogenic sources, such
25 as industrial processes which rely upon the burning of

1 fossil fuels, has increased the concentration of CO₂ in the
2 atmospheric makeup to the point where certain adverse
3 effects are now apparent. The most obvious effect is a
4 phenomena known as "greenhouse effect", a potentially
5 dangerous phenomena which if left unchecked could possibly
6 reap catastrophic consequences upon the human race. This
7 effect is theorized by climatologists to bring about a rise
8 in the mean temperature of the worlds oceans, thereby
9 melting polar ice and increasing the mean sea level of the
10 oceans. In fact, recent independent studies by Russian and
11 American scientists have shown that the prediction of
12 temperature rises in the polar regions have been correct.
13 Sonar readings from British submarines patrolling this
14 region have shown the ice to be one third as thick in the
15 last thirty years. The British have a legitimate concern as
16 the local effect upon Britain will be Russian like winters,
17 replacing the moderate winters of present times. Since the
18 mid-nineteen eighties Eskimos have reported spring arriving
19 one month early, and autumn arriving one month late. It is
20 also theorized that this phenomena will result in a greater
21 number and severity of hurricanes. In fact meteorologists
22 at the Massachusetts Institute of Technology (MIT) have
23 calculated a relationship between sea surface temperatures
24 and the central low pressure of a tropical cyclone. It was
25 shown the cyclone pressures could decrease substantially
26 with increasing sea-surface temperatures. Increases of
27 ocean temperatures of only a few degrees could increase the

1 intensity of hurricanes by as much as 40% based on typical
 2 greenhouse warming projections. In 1998 such a violent
 3 hurricane named "Mitch", caused the devastation of the
 4 entire infrastructure of the Central American country,
 5 Honduras, taking the lives of nearly twenty thousand people
 6 as well. A more recent event in November of 1999, which has
 7 officially been recorded as the most powerful cyclone to
 8 date, struck the nation of India killing twenty thousand
 9 people and left twenty million people homeless. Recent
 10 floods worldwide have been attributed to excess water vapor
 11 in the atmosphere, another predicted result of greenhouse
 12 effect. One such flood in December of 1999, the result of a
 13 torrential downpour, killed an estimated 35,000 people and
 14 left untold hundreds of thousands homeless in and around
 15 Caracas, Venezuela. It is only natural to assume the human
 16 and economic toll will only increase as time goes by with no
 17 effort made to reduce anthropogenic carbon dioxide
 18 emissions. It is entirely possible the effect will
 19 eventually evolve into a stage known as "runaway greenhouse"
 20 which will eliminate all Human life forms from the surface
 21 of the Earth. To the trained eye it is obvious an emergency
 22 situation is eminent.

23 Accordingly, with the demand for electric power
 24 increasing steadily worldwide, thereby increasing the
 25 amount of fossil fuels being burned, it is readily apparent
 26 some corrective measure must be taken to alleviate this
 27 situation. While converting all electric utilities to

1 nuclear power is completely unrealistic, there exists a need
2 in the art for the emergence of fossil fuel burning electric
3 power generation plants which possess the ability to contain
4 all of the resultant emissions, and doing so while operating
5 in an efficient manner. My previously issued U. S. Patents
6 numbered 5,027,720, 5,129,331 and 5,265,424 address this
7 issue to some extent. However, these designs do not
8 adequately address the final disposition of the enormous
9 quantities of carbon dioxide produced by a fossil fuel
10 burning furnace boiler. The inventive system disclosed
11 herein will create useful products from the resultant flue
12 gases. Thus no harmful exhaust gases are permitted to
13 escape into the atmosphere, overcoming the disadvantages of
14 the prior art, and providing a much needed solution to a
15 difficult environmental dilemma.

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17 SUMMARY OF THE INVENTION
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19 It is the object of the present invention to provide an
20 apparatus and method for recycling the flue gases which
21 result from the burning of fossil fuels, whereby the
22 constituent flue gas, carbon dioxide, is prohibited from
23 entering the earth's atmosphere.

24 It is a further object of the invention to utilize a
25 constituent of the flue gas, namely carbon dioxide, as the
26 actual source of power in the process of converting it to a
27 useful product.

1 It is yet another object of the invention to create
2 other useful products from the flue gases whereby the energy
3 penalty of operating the apparatus will be minimized.

4 The objects of the present invention are fulfilled by
5 providing a means and method for extracting and recycling
6 the resultant flue gas stream caused by the burning of
7 fossil fuels such as coal, oil, and natural gas. Included
8 are flue gas cooling and conditioning means. Further
9 included is a fluid conduit means to direct the flow of the
10 fluid process throughout the entire system.

11 Flue gas exits a source which in this example is a
12 furnace boiler system, passing through cyclones to eliminate
13 particulate matter. If natural gas or oil is the fuel being
14 burned, the cyclones are not necessary. Assuming the
15 combustion in the furnace boiler is under stoichiometric
16 conditions, the approximate temperature of the flue gas
17 exiting is 355 degrees Fahrenheit. The flue gas which is a
18 mixture of N_2 , CO_2 , S_2 , and O_2 is then subjected to various
19 stages of heat exchange, cooling and conditioning until the
20 carbon dioxide and nitrogen are the only remaining
21 constituents. If coal is the fuel being burned the remaining
22 mixture is nitrogen (N_2), oxygen (O_2) and CO_2 , with the
23 ratio of N_2 to CO_2 approximately 3:1 in favor of N_2 . If
24 natural gas is the fuel then the remaining gas mixture is
25 N_2 , and CO_2 . Carbon dioxide is separated from the mixture.
26 It should be noted that this operation generally poses a
27 high energy penalty, conversely the mixture will be

1 disassociated in a proprietary process of low energy
2 consumption not within the scope of this patent application.
3 Having separated the mixture, the nitrogen of which an
4 enormous quantity exists, is saved for sale and other uses.
5 The gaseous carbon dioxide is introduced into a laser
6 powered gas converter. The carbon dioxide is utilized as a
7 reactant in the converter wherein it is converted into a
8 hydrocarbon fuel product. The converter is powered by a
9 flowing gas laser otherwise known as a gas dynamic laser,
10 and utilizes in its operation a purified portion of the
11 carbon dioxide from the source. Such a laser is
12 manufactured by United Technologies Inc. and is marketed for
13 industrial uses. The completely assembled gas converter
14 apparatus comprises a means to create a powerful infrared
15 laser beam, and at least one but preferably a plurality of
16 catalytic converters. Any variety of chemical compounds can
17 be created by the converter from selected gases introduced
18 into the device depending upon which catalyst is utilized.
19 The infrared laser beam is passed through a beam splitter
20 forming two beams. In this manner the beam radiates two
21 catalytic converters simultaneously. It should be
22 understood that the beam can be split into several beams and
23 a separate task in another vicinity, such as communications,
24 can be performed with the beam. Other tasks normally
25 associated with a laser can also be performed. The above
26 summary has described the actual creation of a producer gas
27 fuel as well as other useful products from the emissions of

1 a furnace boiler system. Further, utilizing a constituent
2 of the flue gas as the medium in a laser, then as a reactant
3 within a catalytic converter radiated by the laser, is in
4 essence utilizing carbon dioxide to convert itself into
5 fuel, producing a new and surprising result.

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7 BRIEF DESCRIPTION OF THE DRAWINGS

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9 The above and yet other objects of the present
10 invention and the attendant advantages will become more
11 readily apparent by reference to the drawings wherein:

12 Figure 1 is a schematic block diagram indicating
13 interconnected functional components and their positions
14 relative to the inventive system.

15 Figure 2 is a schematic diagram depicting the
16 preferred embodiment of the instant invention.

17 Figure 3 is a partial cutaway view of a second
18 embodiment of inventive system comprising a single laser
19 powered converter element.

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21 DETAILED DESCRIPTION OF THE INVENTION

22 With reference to figure 1 a flue gas source 10 is
23 depicted including furnace 11 wherein fuel mixed with air
24 and burned. The conventional components of the furnace are
25 shown as boiler superheater 12, steam turbine 13,
26 intermediate turbine 13', secondary superheater 14,
27 condenser 15, economizer 16, and air heater 17. The

1 resultant flue gas is made to enter cyclone 18 wherein
2 particulate matter is removed. If the fuel being burned is
3 not coal, then 18 can be eliminated. Induction fan 19 draws
4 the flue gas, which has a temperature of approximately 355
5 degrees Fahrenheit, out of the furnace and forces it into
6 high temperature heat exchanger 21. Heat exchanger 21 which
7 uses water as the exchange medium lowers the temperature of
8 the gas to approximately 175 degrees Fahrenheit while
9 simultaneously producing steam to drive lithium bromide
10 chiller 20 which in turn produces forty degree water.
11 Chiller 20 consumes .006% of power plant output (PPO). Upon
12 exiting the heat exchanger the flue gas proceeds to a
13 fibrous organic waste filter means 27 wherein the flue gas
14 at a temperature of approximately 175 degrees Fahrenheit
15 conditions an organic waste mixture, preparing the mixture
16 for digestion in biogas production unit 30. The biogas
17 production unit otherwise known as a methane digester
18 produces methane gas which is extracted and consumed in fuel
19 cell 31 thereby producing electricity. Other methods of
20 utilizing the fuel can be employed. The fuel cell
21 electrical production is equivalent to 1.1% of PPO and is
22 intended to offset the penalty of operating the entire flue
23 gas conversion system. The biogas production unit also
24 converts the spent fibrous organic waste into enormous
25 amounts of topsoil. Upon leaving the organic waste filter
26 means 27 the flue gas is cooled by pond water in heat
27 exchanger 29 in order to remove the water contained in the

gas. This stage consumes 0.28% of PPO and removes 100% of H₂O plus 10% of SO₂ from the gas. The water now containing SO₂ is directed to sulfur recovery unit 26 where the sulfur is removed. The water is reused. Upon leaving the heat exchanger the temperature of the gas is approximately 150 degrees Fahrenheit. The gas now enters the low temperature heat exchanger 22 where it is cooled to approximately 60 degrees Fahrenheit. This heat exchanger uses the forty degree water produced in chiller 20 as the exchange medium. Immediately thereafter the gas is subjected to an open spray heat exchanger 23 using pond water as the medium of exchange and wherein the remainder of the sulfur dioxide is removed. The sulfur laden water is sent to a sulfur recovery unit 26 where the sulfur is removed and the water returned to the pond. If natural gas is the fuel as illustrated in figure 1 then the remaining gas mixture is already CO₂, and N₂, therefore no heat exchanger 23 or sulfur removal component 26 is required. If coal is being burned in the furnace, the remaining mixture consists of nitrogen (N₂), oxygen (O₂), and CO₂, the ratio between N₂ and CO₂ approximately 3:1, N₂ predominating. A gas separation means 25 now receives the mixture wherein the nitrogen is removed and stored in vessel 50 for sale or other uses. The remaining gas, now a significantly pure form of carbon dioxide, enters gas converter 40 where it is converted to carbon monoxide. With reference to figure 2 the converter 40 is comprised of a flowing gas infrared laser 41, and a first catalytic

converter 42. The flowing gas laser includes a gas inlet 41a and a gas outlet 41b. Carbon dioxide gas flowing through laser 41 exits at gas outlet 41b and is directed through interconnection means 35 which is in communication with the inlet of converter 42. By entering converter 42 the expended laser medium joins the main stream of carbon dioxide gas entering converter 42 as well. In this manner a portion of the actual gas used as the reactant in the catalytic converter is first utilized as a medium for the creation of the laser beam. With further reference to figure 2 beamsplitter 41c, splits the laser beam into multiple separate beams thus allowing laser 41 to accommodate a plurality of catalytic converters. Other distinct tasks normally associated with a laser are possible by spitting the beam, apart from the primary function which is to provide an energy source for catalytic conversion. The laser, otherwise known as a "Gas Dynamic Laser" is of a type manufactured by United Technologies Inc., and is marketed for industrial use. Given the amount of carbon dioxide available, an enormously powerful beam can be created. It is noted here that a plurality of converter 40 may be utilized depending upon the quantity of gas to process. During operation carbon monoxide is produced in a first catalytic converter 42 by passing carbon dioxide over the laser heated catalyst carbon, the chemical equation being $\text{CO}_2 + \text{C} = 2\text{CO}$. Other suitable catalysts can be substituted. Hydrogen is produced in a second catalytic

1 converter 43 by passing steam over the catalyst iron, which
2 is heated by the powerful laser beam created by laser 41,
3 the chemical equation being $4H_2O + 3Fe = Fe_3O_4 + 4H_2$. Here
4 again other suitable catalysts may be substituted. The
5 produced gases are then introduced through compressor 44
6 into mixer 45 where they are chemically combined, thereby
7 producing a hydrocarbon fuel product. The mixer 45 may
8 embody a separate catalytic converter. The product of the
9 reactants is then stored in vessel 55 for the purpose of
10 burning in the furnace boiler. Since each of converter
11 element 42 and 43 can be constructed with a plurality of
12 inlet connection points, another similar technique to
13 manufacture a hydrocarbon fuel product with the apparatus
14 can be employed. This method involves passing both steam
15 and carbon dioxide over a select catalyst of a singular
16 converter element of the reformer 40, thereby resulting in
17 $CO+H_2$ a well known gaseous fuel. Furthermore, the elements
18 Hydrogen, Carbon, Sulfur, Nitrogen, and Oxygen, all of which
19 are mentioned in the foregoing specification, are all
20 capable of being chemically combined in one way or another.
21 Thus, the creation of a myriad of other useful products
22 from the combination of these elements is another distinct
23 possibility.

24 Accordingly, while a preferred embodiment of the
25 present invention is shown and described herein, it will be
26 understood that the invention may be embodied otherwise than
27 as herein specifically illustrated or described, and that